



July 2016

ARMY CORPS OF ENGINEERS

Additional Steps Needed for Review and Revision of Water Control Manuals

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Why GAO Did This Study

The Corps owns and operates water resource projects, including more than 700 dams and their associated reservoirs across the country, for such purposes as flood control, hydropower, and water supply. To manage and operate each project, the Corps' districts use water control manuals to guide project operations. These manuals include water control plans that describe the policies and procedures for deciding how much water to release from reservoirs. However, many of the Corps' projects were built more than 50 years ago, and stakeholders have raised concerns that these manuals have not been revised to account for changing conditions.

The Water Resources Reform and Development Act of 2014 included a provision for GAO to study the Corps' reviews of project operations, including whether practices could better prepare the agency for extreme weather. This report (1) examines the extent to which the Corps has reviewed or revised selected water control manuals and (2) describes the Corps' efforts to improve its ability to respond to extreme weather. GAO reviewed the Corps' guidance on project operations; examined agency practices; and interviewed Corps officials from headquarters, all 8 divisions, and 15 districts—selected, in part, on regional differences in weather conditions.

What GAO Recommends

GAO recommends that the Corps develop guidance on what constitutes a water control manual's review and how to document it and track which manuals need revision. The agency concurred with the recommendations.

What GAO Found

According to U.S. Army Corps of Engineers (Corps) officials, the agency conducts ongoing, informal reviews of selected water control manuals and has revised some of them, but the extent of the reviews and revisions is unclear because they are not documented or tracked, respectively. The Corps' engineer regulations state that water control manuals should be reviewed no less than every 10 years so that they can be revised as necessary. However, officials from all 15 districts GAO interviewed said they do not document informal reviews of water control manuals because they consider such reviews part of the daily routine of operating projects. The Corps does not have guidance, consistent with federal standards for internal control, on what activities constitute a review or how to document the results of reviews. Without such guidance, the Corps does not have reasonable assurance that it will consistently conduct reviews and document them to provide a means to retain organizational knowledge. The Corps' engineer regulations also state that water control manuals shall be revised as needed, but the extent to which manuals have been revised or need revision remains unknown because the Corps' divisions do not track consistent information about manuals. For example, based on GAO's review of the Corps' documents, one of the eight divisions tracked whether the water control plans in its water control manuals reflected actual operations of a project, but the remaining seven did not. While the Corps has revised certain water control manuals as called for by its regulations, district officials GAO interviewed said additional manuals need revision. However, the Corps does not track consistent information on manuals needing revision, in accordance with federal internal control standards. Without tracking which manuals need revision, it is difficult for the Corps to know the universe of projects that may not be operating in a way that reflects current conditions as called for in the Corps' engineer regulations.

The Corps has efforts under way to improve its ability to respond to extreme weather, including developing a strategy to revise drought contingency plans and studying the use of forecasting to make decisions on project operations. To better respond to drought, the Corps is developing a strategy to analyze drought contingency plans in its water control manuals to account for a changing climate. As of May 2016, the Corps was conducting, as a pilot, updates of five projects' drought contingency plans to help test methods and tools for future use in other plans. The Corps is also studying the use of forecasting tools to improve water supply and flood control operations at two projects in California by evaluating if they can retain storm water for future supply as long as the retained water can safely be released, if necessary, prior to the next storm. Knowledgeable stakeholders GAO interviewed said it is important for the Corps to consider forecast-based operations at its projects to help ensure efficient operations and to be able to respond to changing patterns of precipitation. Corps officials said the agency may consider doing so once the two California projects are completed in 2017.

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Abbreviations

Corps	U.S. Army Corps of Engineers
NOAA	National Oceanic and Atmospheric Administration
O&M	operations and maintenance
USGS	U.S. Geological Survey

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July 26, 2016

The Honorable James Inhofe
Chairman
The Honorable Barbara Boxer
Ranking Member
Committee on Environment and Public Works
United States Senate

The Honorable Bill Shuster
Chairman
The Honorable Peter DeFazio
Ranking Member
Committee on Transportation and Infrastructure
House of Representatives

The U.S. Army Corps of Engineers (Corps) is the world's largest public engineering agency, with water resources projects across the United States, including more than 700 dams that it owns and operates for a variety of purposes including navigation, flood control, irrigation, hydropower, water supply, recreation, and fish and wildlife conservation. However, much of the Corps' infrastructure for these dams and their associated reservoirs was built more than 50 years ago. To manage and operate each water resources project, the Corps' 38 district offices develop water control manuals to guide project operations. These manuals describe the project's dams, reservoirs, and any affected rivers; historic floods and storms in the project area; and data from other agencies, such as the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) and the Department of the Interior's U.S. Geological Survey (USGS), that the Corps uses in operating the projects. The manuals also, among other things, describe methods for forecasting the amount of runoff flowing to the dams' reservoirs,¹ document policies and procedures for deciding how much water to release from the reservoirs, and generally have an associated drought contingency plan that provides guidance for district actions in response to periods of water shortages. Stakeholders, such as local governments and

¹Runoff flows over the land surface, going downhill into rivers and streams.

advocacy groups, have raised concerns that some water control manuals have not been revised since projects were built decades ago and may not reflect advances in science, such as in weather forecasting or changes in weather patterns.

In addition, the Corps' projects may be affected by extreme weather events, such as flood and drought. According to the U.S. Global Change Research Program's May 2014 National Climate Assessment and a 2010 National Research Council's report, precipitation patterns are changing, and the frequency and intensity of some extreme weather events are increasing.² In addition, a 2009 USGS report found that changes in the climate could affect water resources management and require changed operational assumptions about resource supplies, system demands or performance requirements, and operational constraints.³ For example, according to the report, a shift in precipitation from snow to rain, combined with earlier melting of mountain snowpack, has been documented in western states. These two reported actions change the timing of runoff, affecting the Corps' operational decisions about when to release water from reservoirs.

Section 1046 of the Water Resources Reform and Development Act of 2014 includes a provision for us to audit the Corps' reviews of project operations, including an assessment of whether the Corps' practices could result in greater efficiencies to better prepare for extreme weather. According to a 1992 Corps' report,⁴ project operations are defined as

² Jerry M. Melillo, Terese (T.C.) Richmond, and Gary W. Yohe, eds., 2014: *Climate Change Impacts in the United States: The Third National Climate Assessment*, (Washington, D.C.: U.S. Global Change Research Program, May 2014) and National Research Council, Board on Atmospheric Sciences and Climate, *Advancing the Science of Climate Change* (Washington, D.C.: National Academies Press, 2010). The U.S. Global Change Research Program coordinates and integrates the activities of 13 federal agencies that conduct research on changes in the global environment and their implications for society. The National Research Council is now known as the National Academies of Sciences, Engineering, and Medicine.

³ L.D. Brekke, J.E. Kiang, J.R. Olsen, R.S. Pulwarty, D.A. Raff, D.P. Turnipseed, R.S. Webb, and K.D. White, *Climate Change and Water Resources Management—A Federal Perspective: USGS Circular 1331* (2009).

⁴ Army Corps of Engineers, *Authorized and Operating Purposes of Corps of Engineers Reservoirs* (Washington, D.C.: July 1992). This report excludes water control structures that do not routinely impound water, such as river diversion structures and pumping stations.

water control management that is routinely required to control either water level or flow, or both. Our report (1) examines the extent to which the Corps has reviewed or revised selected water control manuals and (2) describes the Corps' efforts, if any, to improve its ability to respond to extreme weather. Section 1046 of the Water Resources Reform and Development Act of 2014 also required the Corps to update its 1992 report about authorized and operating purposes of its reservoirs by June 10, 2016. The updated report is, among other things, to include a plan for reviewing the operations of individual projects that meet specified requirements.⁵ The act also includes a provision for us to review the plan in the updated report. However, according to officials from the Corps and from the office of the Assistant Secretary of the Army for Civil Works, the Corps did not update the report as required by the statutory deadline because of funding constraints; therefore, we were unable to review the updated report.

To address both objectives, we reviewed relevant laws and executive orders, as well as our past reports on Corps operations and preparation for extreme weather. We interviewed officials who are responsible for project operations at headquarters and all eight Corps divisions. In addition, we interviewed officials from a nonprobability sample of 15 of the 38 Corps districts responsible for water control management.⁶ We selected these districts based on criteria such as the Corps division where the district resides, regional differences in weather conditions, and a range in the number of projects operating within the district. Because this was a nonprobability sample, our findings cannot be generalized to all Corps districts but provide illustrative examples of the Corps' actions and strategies. We also visited two district offices (Los Angeles and Sacramento Districts) from our sample, where we reviewed documents, interviewed agency officials, and observed some of the Corps' efforts to help prepare its operations for extreme weather. We selected these offices based on available resources and proximity to a GAO field office,

⁵Pub. L. No. 113-121, § 1046(a)(2)(B)(ii)(I)(dd) (2014).

⁶We interviewed Corps officials from the following districts: Anchorage, Alaska; Philadelphia, Pennsylvania; Jacksonville, Florida; Walla Walla, Washington; St. Louis, Missouri; Los Angeles, California; Sacramento, California; Kansas City, Missouri; Fort Worth, Texas; Concord, Massachusetts; St. Paul, Minnesota; Louisville, Kentucky; Tulsa, Oklahoma; Pittsburgh, Pennsylvania; and Mobile, Alabama.

in addition to the criteria used to select the nonprobability sample of districts. The results from these visits are also not generalizable.

To examine the extent to which the Corps has reviewed and revised selected water control manuals, we reviewed relevant Corps guidance and other documents, and information on water control manual reviews or revisions, such as engineer regulations, circulars, and manuals. We compared agency practices with federal standards for internal control.⁷ We focused on steps taken since 1990 because of enacted legislation that changed the Corps' process to revise water control manuals and because 1990 was the last time the Corps systematically prepared drought contingency plans for water control manuals.⁸ In addition, we examined the Corps' relevant documents and information on water control manual reviews and revisions from each of the eight divisions and our nongeneralizable sample of districts.

To examine the Corps' efforts, if any, for improving its ability to respond to extreme weather, we examined the Corps' relevant guidance, documents, and information on project operations and efforts to prepare for or respond to extreme weather. We interviewed cognizant Corps officials to discuss what, if any, guidance is being drafted or implemented responding to extreme weather events at the Corps' projects. We also interviewed five knowledgeable stakeholders from academia, a consulting firm, and a federal science agency to obtain their views on leading practices in preparing operations for extreme weather. Knowledgeable stakeholders were selected based on their knowledge of reservoir operations, modeling precipitation patterns, and Corps operational decisions. Views from these knowledgeable stakeholders are not generalizable to those with whom we did not speak.

We conducted this performance audit from August 2015 to July 2016 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain

⁷GAO, *Standards for Internal Control in the Federal Government*, [GAO/AIMD-00-21.3.1](#) (Washington, D.C.: Nov. 1, 1999). GAO has revised and reissued *Standards for Internal Control in the Federal Government*, with the new revision effective as of October 1, 2015. [GAO-14-704G](#) (Washington, D.C.: September 2014).

⁸Pub. L. No. 101-640, tit. III, § 310 (1990) (codified as amended at 33 U.S.C. § 2319).

sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

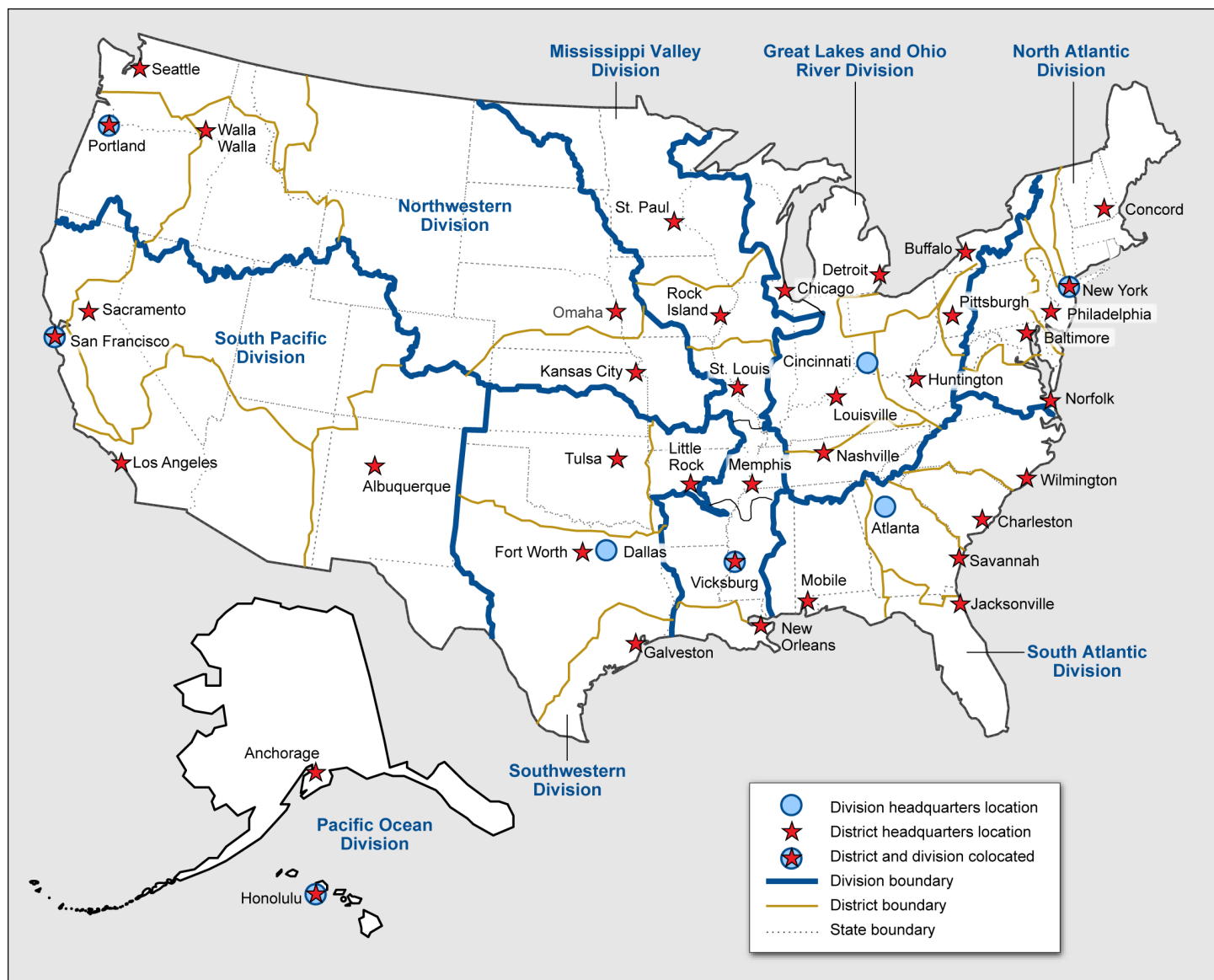
This section provides information on the Corps' organizational structure, its project operations and water control manuals, and the process for formulating its operations and maintenance budget.

Corps' Organizational Structure

Located within the Department of Defense, the Corps has both military and civilian responsibilities.⁹ The Corps' civil works program is organized into three tiers: a national headquarters in Washington, D.C.; eight regional divisions that were established generally according to watershed boundaries; and 38 districts nationwide (see fig. 1).

⁹The Corps' military program provides, among other things, engineering and construction services to other U.S. government agencies and to foreign governments. This report focuses only on the Corps' civil works program.

Figure 1: Locations of the U.S. Army Corps of Engineers' Civil Works Divisions and Districts



Sources: U.S. Army Corps of Engineers; Map Resources (map). | GAO-16-685

Corps headquarters primarily develops policies and provides oversight. The Assistant Secretary of the Army for Civil Works, appointed by the President, establishes the policy direction for the civil works program. The Chief of Engineers, a military officer, oversees the Corps' civil works

operations and reports on civil works matters to the Assistant Secretary of the Army for Civil Works. The eight divisions, commanded by military officers, coordinate civil works projects in the districts within their respective divisions. Corps districts, also commanded by military officers, are responsible for planning, engineering, constructing, and managing water-resources infrastructure projects in their districts. Districts are also responsible for coordinating with projects' nonfederal sponsors, which may be state, tribal, county, or local governments or agencies.¹⁰

In 1969, the Corps formed the Institute for Water Resources—which is a field-operating activity outside of the headquarters, division, and district structure—to provide forward-looking analysis and research in developing planning methodologies to aid the civil works program. Specifically, the institute fulfills its mission, in part, by providing an analysis of emerging water resources trends and issues and state-of-the-art planning and hydrologic-engineering methods, models, and training. In 2009, the Corps established the Responses to Climate Change program under the lead of Institute for Water Resources to develop and implement practical, nationally consistent, and cost-effective approaches and policies to reduce potential vulnerabilities to the nation's water infrastructure resulting from climate change and variability.

Project Operations and Water Control Manuals

The Corps is responsible for operations at 707 dams that it owns at 557 projects across the country, as well as flood control operations at 134 dams constructed or operated by other federal, nonfederal, or private agencies. Each of these projects may have a single authorized purpose or serve multiple purposes such as those identified in the original project authorization, revisions within the discretionary authority of the Chief of Engineers, or project modifications permitted under laws enacted subsequent to the original authorization. For example, the Blackwater Dam in New Hampshire has the single purpose of flood control, whereas the Libby Dam in Montana has multiple purposes, including hydropower, flood control, and recreation.

¹⁰Nonfederal sponsors are those entities that share the cost of planning and implementing Corps projects. The division of federal and nonfederal cost-sharing required varies by project purpose.

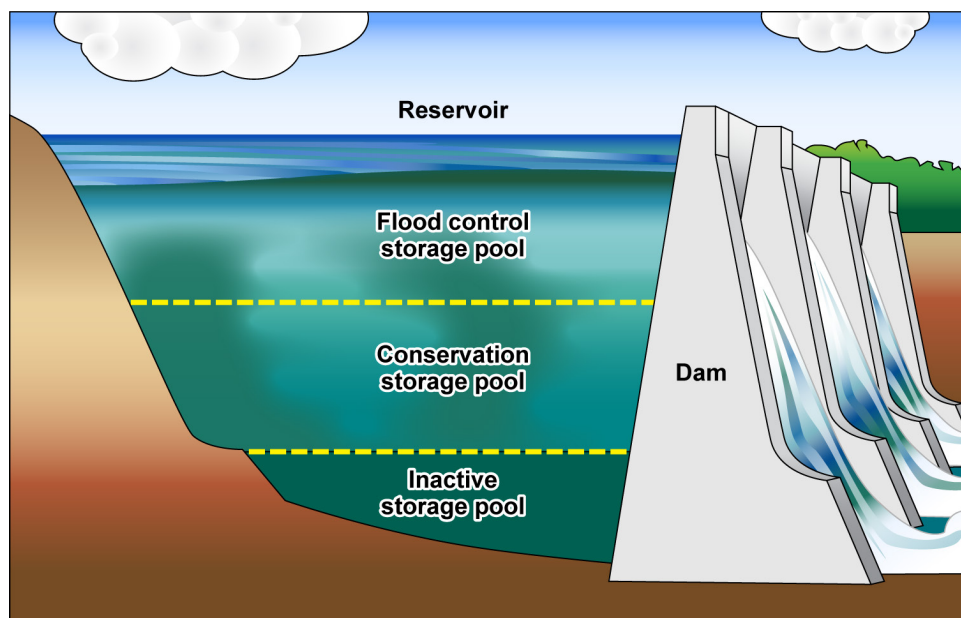
These 841 dams and their reservoirs are operated according to water control manuals and their associated water control plans, which Corps regulations require to be developed.¹¹ A water control manual may outline operations for a single project or a system of projects. For example, the Missouri River Mainstem Reservoir System Master Water Control Manual outlines the operations at six dams and their associated reservoirs, and the Folsom Dam Water Control Manual applies to one dam and its reservoir. Water control manuals include a variety of information the Corps uses in operating the dams, including protocols for coordinating with and collecting data from federal agencies, such as NOAA's National Weather Service and USGS, as well as water control plans. The water control plans, sometimes referred to as chapter 7 of the water control manuals, outline how each reservoir is to be operated and include relevant criteria, guidelines, and rule curves defining the seasonal and monthly limits of storage and guide water storage and releases at a project. According to the Corps' engineer regulations, the Corps develops water control plans to ensure that project operations conform to objectives and specific provisions of authorizing legislation. Water control plans also generally describe how a reservoir will be managed, including how water is to be allocated between a flood control storage pool and a conservation storage pool, which is used to meet project purposes during normal and drought conditions.¹² The bottom of a conservation storage pool is considered inactive and is designed for collecting sediment (see fig.2). Water levels in the pools are defined based on a statistical analysis of historical rain events. For those projects that have multiple authorized purposes, water control plans attempt to balance water storage for all purposes.

¹¹33 C.F.R. § 222.5(f)(1).

¹²The flood storage pool captures intense rainfall and provides flood risk reduction for downstream areas. The conservation storage pool may be used for hydropower generation, water supply, recreation, fish and wildlife habitat enhancement, and navigation, among other uses.

Figure 2: Illustration of a U.S. Army Corps of Engineers' Reservoir, with Pools Allocated for Different Uses

The conservation storage pool may be used for hydropower generation, water supply, recreation, and navigation, among other uses, and the inactive storage pool collects sediment.



Source: GAO. | GAO-16-685

Corps engineer regulations require that all water control manuals—except manuals for dry reservoirs that do not fill with water unless floodwaters must be contained—have an associated drought contingency plan to provide guidance for water management decisions and responses to a water shortage due to climatological drought.¹³ These plans, which can cover more than one project: (1) outline the process for identifying and monitoring drought at a project, (2) inform decisions taken to mitigate drought effects, and (3) define the coordination needed with stakeholders

¹³U.S. Army Corps of Engineers, *Engineering and Design: Water Control Management*, Engineer Regulation 1110-2-240 (Washington, D.C.: June 30, 2014) and *Engineering and Design: Drought Contingency Plans*, Engineer Regulation 1110-2-1941 (Washington, D.C.: Sept. 15, 1981). The Corps updated Engineer Regulation 1110-2-240 on May 30, 2016.

and local interests to help manage water resources so they are used in a manner consistent with the needs that develop, among other things.

According to a 2014 Corps engineer regulation,¹⁴ water control manuals may be revised for reasons such as land use development in the project area and downstream from it, improvements in technology used to operate projects, reallocation of the water supply,¹⁵ new regional priorities, or changes in environmental conditions. The Corps' engineer regulation also directs districts to include in water control manuals a provision allowing temporary deviations from a project's approved water control plan to alleviate critical situations, such as a flood or drought, or to realize additional efficiencies without significantly affecting the project's authorized purposes. Districts are to perform a risk and uncertainty analysis to determine the potential consequences of such a deviation. Division commanders are responsible for reviewing and approving any proposed deviations. According to the engineer regulation, deviations are meant to be temporary and, if a deviation lasts longer than 3 years, the water control manual must be revised.

Corps' Operations and Maintenance Budget Formulation Process

Our prior work has found that the Corps' headquarters, divisions, and districts are all involved in developing the President's budget request for the Corps.¹⁶ The development process spans 2 years; for example, development of the fiscal year 2018 budget began in fiscal year 2016. After receiving budget guidance from the Office of Management and Budget as well as the Assistant Secretary of the Army for Civil Works, district staff compile a list of operations and maintenance (O&M) projects necessary in their districts and submit their needs to the relevant division. O&M projects may include, among other things, water control manual revisions, dredging, replacement of dam parts, dam safety measures, or

¹⁴Engineer Regulation 1110-2-240.

¹⁵Reallocation of water supply storage occurs when the storage is changed from one authorized purpose to a different authorized use. For example, to meet increased demand for water by cities, water storage within a reservoir may be reallocated from hydropower to municipal and industrial use.

¹⁶GAO, *Army Corps of Engineers: Budget Formulation Process Emphasizes Agencywide Priorities, but Transparency of Budget Presentation Could Be Improved*, [GAO-10-453](#) (Washington, D.C.: Apr. 2, 2010).

adding capacity at hydropower projects. Division staff then rank the O&M projects from all districts in the division and submit those rankings to Corps headquarters staff for review. Headquarters staff review the rankings to help ensure they are consistent with Corps-wide guidance and result in decisions that emphasize agency-wide priorities. Headquarters staff consolidate the O&M requests across business lines and divisions into a highest-priority grouping. Once the Corps completes its internal review of the budget request, the Assistant Secretary of the Army for Civil Works approves and submits its budget to the Office of Management and Budget for review. The Office of Management and Budget recommends to the President whether to support or change the Corps' budget request, and the President's budget request is transmitted to Congress.

The Extent to Which the Corps Has Reviewed or Revised Water Control Manuals Is Unclear Because It Did Not Document Reviews or Track Revisions

According to agency officials, the Corps conducts ongoing, informal reviews of selected water control manuals and has revised some of them, but the extent of the reviews and revisions is unclear because they were not documented or tracked. More specifically, district officials said that the Corps reviews the manuals as part of daily operations but does not document the reviews, and there is no guidance on what constitutes a review or how to document it. Further, the Corps does not track consistent information across divisions on the status of manuals to indicate revisions that were made or are needed.

The Extent to Which the Corps Has Reviewed Its Water Control Manuals Is Unclear Because the Reviews Were Informal, According to Agency Officials, and Not Documented

It is unclear to what extent the Corps has reviewed its water control manuals because district officials did not document these reviews, which, according to district officials, are informal and conducted on an ongoing basis through daily operations. A 2014 Corps engineer regulation states that water control manuals should be reviewed no less than every 10 years, so that they can be revised as necessary.¹⁷ Most district officials we interviewed said that they informally review the water control plan because this portion of the manual describes how projects are to be operated under different conditions to meet their authorized purposes. However, officials we interviewed from all 15 districts said they do not document these informal reviews because they consider such reviews to be part of the daily routine of operating projects. Because these informal reviews are not documented, knowledge of these reviews and their results may be limited to personnel directly involved with them. Officials we interviewed from four districts said that the loss of institutional knowledge posed a challenge to conducting efficient reviews of manuals. For example, officials from one district said that no Corps officials currently employed at the district had worked on developing the manual for a project and had no supporting documentation of the process, so the officials did not know why prior Corps officials wrote the manual in a particular way. As a result, the officials said it took them longer to review the manual.

One Corps district we reviewed had previously documented informal reviews of water control manuals. Specifically, officials we interviewed in this district said that they documented reviews of some water control manuals in 2005 as part of a district-wide effort to ensure these manuals were adequate to meet the projects' authorized purposes since they had not been revised in a long time. According to these officials, as part of this effort, if they determined that all of the operating conditions in a manual were still current, they submitted a memorandum to their division that revalidated the manual's water control plan. Officials from that district said they have not documented reviews of water control manuals since 2005 because they chose to focus only on those manuals they knew needed revision. However, the Corps does not have guidance on what activities constitute a review or how officials should document the results of their reviews. Under federal standards for internal control, internal control and

¹⁷Engineer Regulation 1110-2-240.

other significant events are to be clearly documented in a manner that allows the documentation to be readily available for examination, such as in management directives, administrative policies, or operating manuals.¹⁸ Without developing guidance on what activities constitute a review of a water control manual and how to document that review, the Corps does not have reasonable assurance that its districts will consistently conduct reviews and document them to provide a means to retain organizational knowledge and mitigate the risk of having that knowledge limited to personnel directly involved with these reviews.

The Corps Has Revised Some Water Control Manuals but Does Not Track Consistent Information on Which Have Been Revised or Need Revision

The Corps has revised some water control manuals; however, divisions and districts do not track consistent information about revisions to manuals, and the extent to which they have been revised—or need revision—is unclear. Corps engineer regulations state that manuals are to be revised as needed, in accordance with the regulations.¹⁹ Districts have revised some water control manuals for a variety of reasons, such as in response to infrastructure modifications and weather events, according to the Corps' documents and its headquarters, division, and district officials we interviewed. For example, officials we interviewed in one district said they revised a water control manual after a flood highlighted a need to change the seasonal and monthly limits of reservoir storage when water recedes. Officials we interviewed from other districts said they revised a manual based on vulnerabilities identified through the periodic inspections they conduct of projects through the Corps' dam safety program.²⁰

District officials we interviewed said that the time and resources needed to revise manuals vary greatly, depending on the nature of the revisions

¹⁸[GAO/AIMD-00-21.3.1](#).

¹⁹Engineer Regulation 1110-2-240; U.S. Army Corps of Engineers, *Engineering and Design: Management of Water Control Systems*, Engineer Manual 1110-2-3600 (Washington, D.C.: Nov. 30, 1987).

²⁰The Corps is required by law to carry out a national program of inspection of dams for the purpose of protecting human life and property. 33 U.S.C. § 467a. Through this program, the Corps conducts: (1) annual inspections to ensure that a dam is being properly operated and maintained; (2) periodic inspections every 5 years, including a more detailed, comprehensive evaluation of the condition of the dam; and (3) risk assessments every 10 years, including the probability of failure and resulting potential consequences due to failure.

and the complexity of the project, among other things. For instance, according to a Corps 2012 engineer regulation,²¹ all revisions to a water control manual are to undergo a quality control review of the science and engineering work by district leadership. Depending on the revisions made, manuals may also undergo a technical review by division leadership and an independent external peer review by a panel of experts. For example, according to a Corps engineer regulation and division and district officials we interviewed,²² if the districts make substantial revisions to a manual's water control plan, they are to complete environmental analyses required by the National Environmental Policy Act of 1969,²³ which they said involves considerable time and coordination with other federal agencies and opportunity for public comment. District officials told us that making such substantive revisions to a manual takes more time and resources than making an administrative revision because of the additional requirements for review.²⁴

Moreover, some district officials noted that the longer they defer making revisions to a manual, the more extensive and complex the changes may become, changes that may add time and increase costs to revise the manual. Officials in one district said that it cost about \$100,000 to revise one section of a manual's water control plan, which did not significantly affect other aspects of the plan. In contrast, officials in another district said that it cost over \$10 million and took over 25 years to revise a manual that included a water control plan for several projects, primarily because of litigation over the revisions.

Our review of division documents indicates that all eight divisions we reviewed tracked the date a manual was last revised, but officials told us that the length of time since the last revision is not necessarily indicative

²¹U.S. Army Corps of Engineers, *Water Resources Policies and Authorities: Civil Works Review*, Engineer Circular 1165-2-214 (Washington, D.C.: Dec. 15, 2012).

²²Engineer Regulation 1110-2-240.

²³Pub. L. No. 91-190, 83 Stat. 852 (1970) (codified as amended at 42 U.S.C. §§ 4321-4347).

²⁴Revisions to water control manuals can be administrative, such as updating contact information, or substantive, which would change the water control plan of the project, according to Corps documents.

of whether manuals need to be revised. According to headquarters and district officials we interviewed, water control manuals are designed to provide flexibility for a broad variety of runoff and climatic conditions. For example, headquarters officials said the rule curve²⁵ in one water control manual provided guidelines for how much water operators should take out of the reservoir during October and November to meet its flood risk management target, while at the same time holding enough water to, among other things, meet its authorized purposes of hydropower and providing water flow for an endangered fish species. However, two knowledgeable stakeholders we interviewed said that many of the Corps' rule curves assume that the chances of an extreme event are equally likely for any given year, which may not reflect actual conditions. These stakeholders said that the Corps should consider revising water control manuals with dynamic rule curves to account for potential changes to climate conditions,²⁶ but a Corps official said that the science behind dynamic rule curves is still being developed.

In addition, Corps officials said that the provisions in water control manuals that allow temporary deviations from water control plans, if necessary, provide districts with flexibility in operating projects. For example, in response to drought conditions, the Corps approved a deviation from the water control plan in December 2014 at a project in California, a deviation that allowed the Corps to temporarily retain water captured behind the dam following a rainstorm. According to officials in that district, this temporary deviation allowed them to respond to the immediate stakeholder interests in conserving water during the drought, so they did not need to revise the water control manual. Given the flexibilities provided by rule curves and temporary deviations, not all manuals need to be revised, according to Corps officials we interviewed at headquarters, divisions, and districts.

However, the extent to which water control manuals have been substantively revised, if at all, remains unknown because the divisions and districts we reviewed did not track consistent information about

²⁵Rule curves define the seasonal and monthly limits of water storage and guide water storage and releases at a project.

²⁶Dynamic rule curves change based on the present state of a system, such as storage levels, current inflow, or forecasted conditions.

revisions to water control manuals to help ensure that manuals are revised in accordance with engineer regulations. For example, based on our review of Corps documents, one of eight divisions tracked whether the water control plans in its water control manuals reflected actual operations of the project, but the remaining seven divisions did not. In addition, another division tracked information about when the water control manuals in five out of six of its districts had been revised. Officials whom we interviewed from this division said they were not sure if any of the manuals in the sixth district had been reviewed because information had not been submitted by the district. Corps headquarters officials said that the Corps does not track the status of water control manual revisions agency-wide because two people in headquarters oversee all of the Corps' water resources operational issues, among other duties, and, therefore, divisions and districts were given responsibility for tracking revisions. However, these officials said the agency is compiling information to create a central repository of water control manuals, among other things, to respond to activities set forth in an action plan for the President's Memorandum on drought resilience.²⁷ They said the repository could be used to track the status of revisions or needed revisions of manuals, but they do not currently plan to do so.

Furthermore, district officials we interviewed told us they have identified certain manuals needing revision, but they have not received the O&M funds they requested to revise these manuals and documentation shows that they do not track consistent information on these manuals. A Corps engineer manual states that there may be reasons—such as new hydrologic data or a reevaluation of water control requirements—to revise water control manuals to reflect current operating conditions.²⁸ Divisions are responsible for prioritizing the O&M funding requests they receive from all of their districts. Corps budget documents describe factors to consider for agency-wide prioritization—such as whether an item is required to meet legal mandates or would help ensure project safety (e.g., by paving a project access road)—but headquarters officials said each

²⁷The White House, *Long-Term Drought Resilience: Federal Action Plan of the National Drought Resilience Partnership* (Washington, D.C.: March 2016). The President's Memorandum on Building National Capabilities for Long-Term Drought Resilience establishes federal drought resilience goals, among other things.

²⁸Engineer Manual 1110-2-3600.

division may add other factors for consideration. According to our document review, one of the eight divisions tracked the priority that districts assigned to revising water control manuals when requesting O&M funds during the budgeting process, and four divisions tracked the fiscal year they proposed revising certain manuals, pending available funding. However, most district officials we interviewed said revisions to water control manuals are often a lower priority than other O&M activities, such as equipment repairs, sediment removal, or levee repairs. As a result, districts may not get funding to revise water control manuals.

Moreover, Corps headquarters officials said that each division and district varies in the resources and staff it has available to conduct water control manual reviews and make revisions. For example, officials we interviewed from two districts in the same division said they do not have staff available to review water control manuals, and they have not received the funding they requested to revise their water control manuals. Corps headquarters officials said they do not track which manuals the districts have requested funds to revise—and therefore cannot prioritize these requests—because they have limited staff to accomplish water resources management activities. However, internal control standards in the federal government call for agencies to clearly and promptly document transactions and other significant events from authorization to completion.²⁹ Without tracking which manuals need revision, it is difficult for the Corps to know the universe of projects that may not be operating in a way that reflects current conditions as called for in the Corps' engineer manual and prioritize revisions as needed.

District officials whom we interviewed said that not revising water control manuals regularly could lead projects to operate inefficiently under changing conditions. For example, farmers downstream from one project wanted the Corps to consider changing operations so that their fields would not flood when it rained. However, officials in that district said they requested but did not receive the funds to revise the manual and could not fully address the farmers' concerns. Officials in another district said they have requested funds to revise several manuals that they described as outdated, but because they have not received funds, they noted they were operating those projects in a way that differed from some aspects of

²⁹ [GAO/AIMD-00-21.3.1](#).

the approved water control plans and they did not request deviations. Instead, they said they referred to handwritten notes and institutional knowledge to operate those projects. For example, officials said that due to sedimentation build up in the reservoir of one project, they are operating that project 22 feet higher than the approved plan. According to a Corps engineer regulation, the Corps develops water control plans to ensure that project operations conform to objectives and specific provisions of authorizing legislation.³⁰ However, because some manuals that need revision have not been revised and, as some district officials noted, operations for certain projects differ from aspects of the approved water control plans in those manuals, the Corps lacks assurance that project operations are conforming to the objectives and specific provisions of authorizing legislation.

The Corps Has Efforts Under Way to Improve Its Ability to Respond to Extreme Weather

The Corps has efforts under way to improve its ability to help respond to extreme weather events. These efforts include developing a strategy to revise its drought contingency plans and studying the use of forecasts to make decisions on project operations. The Corps is also conducting research on how to better prepare operations for extreme weather.

The Corps Is Developing a Strategy to Revise Drought Contingency Plans and Is Studying the Use of Forecasts to Make Operations Decisions at Two Projects

To better respond to drought, the Corps is developing a strategy to analyze drought contingency plans in its manuals and devise methods for those plans to account for a changing climate. According to a 2015 Corps report on drought contingency planning, the Corps is developing the strategy because climate change has been and is anticipated to continue to affect the frequency and duration of drought in the United States.³¹ The Corps last systematically prepared drought contingency plans in the 1980s through the early 1990s, before climate change information was widely available. These plans assumed that historic patterns of temperature, precipitation, and drought provided a reasonably accurate

³⁰Engineer Regulation 1110-2-240.

³¹U.S. Army Corps of Engineers, *USACE Drought Contingency Planning in the Context of Climate Change*, Civil Works Technical Report, CWTS 2015-15, (Washington, D.C.: Sept. 2015).

model of future conditions. According to the Corps' 2015 report, the agency subsequently identified and reviewed all of its drought contingency plans. The Corps' review found (1) that none of the plans contained information on drought projections under future climate change and (2) that it was unlikely that the plans provided an adequate guide for preparing for future droughts.

As of May 2016, the Corps was conducting pilot updates of drought contingency plans at five high-priority projects to help test methods and tools for those plans to account for a changing climate. According to the Corps' 2015 report, these pilot projects will help the agency develop a framework for a systematic update of drought contingency plans. Corps officials said these pilots are to be largely completed by the end of calendar year 2016. The Corps has created an internal website available to all Corps officials to disseminate the results of the drought contingency plan analysis, pilot project results, and other drought-related information. In addition to completing the pilot projects, Corps officials said the agency plans to compile a list of drought contingency plan priorities by the middle of fiscal year 2017 for inclusion in the fiscal year 2018 budget.

In addition to its efforts related to drought contingency plans, the Corps is studying the use of forecasting tools to determine whether water control manuals can be adjusted to improve water-supply and flood-control operations at two projects in California—Folsom Dam and Lake Mendocino.³² The Corps has historically used forecasts to some degree in its operations, largely by using models that create a single forecast based on the existing hydrologic data. According to Corps officials, the Folsom Dam and Lake Mendocino projects are evaluating the potential to incorporate forecasts into their operational rules, by using statistical techniques to simulate multiple, slightly different initial conditions and identify a range of potential outcomes and their probability. The use of forecasts at these projects will depend on whether the skill of the forecasts is improved to the point where they are viable in informing

³²The Corps is undertaking this effort at Folsom Dam because the Water Resources Development Act of 1999 requires the Secretary of the Army to update the Dam's flood management plan to reflect improved weather forecasts, among other things. Pub. L. No. 106-53, §101(a)(6)(E), 113 Stat. 269, 274 (1999). According to Corps officials, the Lake Mendocino effort began at the request of the County of Sonoma.

reservoir operations.³³ Corps officials told us that the forecasts must be accurate in terms of space and time to allow the reservoirs to retain some water for future supply as long as the retained water can be safely released, if necessary, prior to the next storm.

At the first project, Folsom Dam, the Corps and the Department of the Interior's Bureau of Reclamation are constructing an auxiliary spillway project to improve the safety of the dam and reduce the flood risk for the Sacramento area.³⁴ Officials also said the water control manual must be updated to reflect the physical changes to the project, but the Corps is also considering incorporating forecasting into its operating rules so that prior to storm events, water can be released earlier than without forecasting capabilities. Corps officials said the revisions to the Folsom Dam water control manual, outlining the forecast-based operations, are estimated to be completed in April 2017. For the second project, Lake Mendocino, an interagency steering committee was formed to explore methods for better balancing water supply needs and flood control by using modern forecasting observation and prediction technology. Corps officials told us the interagency committee expects to complete a preliminary viability study on the project by the end of calendar year 2017.

Corps headquarters officials said that once they determine how forecasting can be incorporated into these projects, the agency may consider using forecast-based operations at other projects. Four of the five knowledgeable stakeholders we interviewed said that it would be important for the Corps to consider using such operations to help ensure efficiency and to be able to respond to changing patterns of precipitation. These views are consistent with our 2014 report on the Missouri River flood and drought of 2011 to 2013, in which we recommended that the

³³Forecasting skill is the statistical evaluation of the accuracy of forecasts or the effectiveness of detection techniques.

³⁴The Bureau of Reclamation has carried out its mission to manage, develop, and protect water and related resources in 17 western states since 1902. The agency has led or provided assistance in constructing most of the large dams and water diversion structures in the West for the purpose of developing water supplies for irrigation, as well as for other purposes, including hydroelectric power generation, municipal and industrial water supplies, recreation, flood control, and fish and wildlife enhancement. For more information, see GAO, *Bureau of Reclamation: Availability of Information on Repayment of Water Project Construction Costs Could Be Better Promoted*, [GAO-14-764](#) (Washington, D.C.: Sept. 8, 2014).

Corps evaluate forecasting techniques that could improve its ability to anticipate weather developments for certain projects.³⁵ However, Corps officials and knowledgeable stakeholders also said that the Corps faces two key challenges in implementing forecast-based operations at its reservoirs. First, four of the five knowledgeable stakeholders we interviewed said that the Corps' primary mission of flood control makes it difficult for the agency to accept the uncertainty that is involved with forecasting. Second, forecasting may be more complex in certain regions of the country, because according to one knowledgeable stakeholder and Corps officials, much of the rain in California is a result of atmospheric rivers,³⁶ which produce rainfall that is more predictable than the convection rains that are experienced in the Midwest.³⁷

The Corps Is Conducting Research on How to Better Prepare Operations for Extreme Weather

The Corps' Responses to Climate Change program is conducting research on adaptation measures through vulnerability assessments for inland projects and sedimentation surveys.³⁸ In 2012, the Corps initiated an initial vulnerability assessment that focused on how hydrologic changes due to climate change may impact freshwater runoff in some watersheds. This assessment identified the top 20 percent of watersheds most vulnerable to climate change for each of the Corps' business lines.³⁹ According to Corps officials, this assessment was conducted for watersheds, because actionable science was not currently available to conduct such an assessment at the project level. However, the Corps is working with an expert consortium of federal and academic

³⁵GAO, *Missouri River Flood and Drought: Experts Agree the Corps Took Appropriate Action, Given the Circumstances, but Should Examine New Forecasting Techniques*, [GAO-14-741](#) (Washington, D.C.: Sept. 12, 2014). The Department of Defense agreed with our recommendation to evaluate the pros and cons of forecasting techniques.

³⁶Atmospheric rivers are relatively narrow regions in the atmosphere that are responsible for most of the horizontal transport of water vapor outside of the tropics.

³⁷In meteorology, the term convection is used specifically to describe vertical transport of heat and moisture in the atmosphere, especially by updrafts and downdrafts in an unstable atmosphere.

³⁸Vulnerability assessments identify, quantify, and prioritize the vulnerabilities in a system. Sedimentation surveys determine the amount of sediment that is in a reservoir.

³⁹U.S. Army Corps of Engineers' business lines include flood risk reduction, navigation, ecosystem restoration, hydropower, recreation, regulatory, water supply, and emergency management.

organizations—including NOAA, the Bureau of Reclamation, USGS, the University of Washington, and the University of Alaska—to develop future projected climatology and hydrology at finer scales. This project is intended to provide the Corps and its partners and stakeholders with a consistent, 50-state strategy to further assess vulnerabilities, a strategy that will also support planning and evaluation of different adaptation measures to increase resilience to specific climate threats. According to the Corps, this consortium holds monthly meetings to review progress made by the various members. According to Corps officials, the consortium plans to release reports in 2016 and 2017 that will enable the Corps to improve tools, methods, and guidance for finer-resolution analyses using climate-impacted hydrology.

The Corps has also begun to evaluate reservoir vulnerabilities to altered sedimentation rates resulting from extreme weather and land use changes. In 2012, the Corps began conducting 15 pilot studies at various districts to test different methods and serve as a framework for adapting to climate change. Two of these pilots predicted changes in the amount of sediment in a reservoir because of changes in hydrologic variables as a result of climate change. Additionally, according to the Corps' website, reservoirs in areas with drought conditions have experienced lower-than-normal levels of water in their conservation storage pools. These lower levels have revealed additional and unexpected sedimentation in reservoirs that could reduce the space available to store water. In 2013, the Corps developed a program to deploy airborne laser scanning systems to measure and collect data on the reservoirs in drought-affected areas. In 2015, this system was tested in California to refine the process to collect sedimentation data and modify the system for specific aircraft. According to a Corps official we interviewed in the Responses to Climate Change program, the agency plans to further refine the data collected and evaluate how these data change over time. This effort, the official told us, is also expected to provide indicators to support the analysis of future sedimentation rates based on climate changes for use in the Corps' climate vulnerability analysis. The official said a baseline report on the Corps' reservoir sedimentation status is expected by the end of fiscal year 2016. This effort was highlighted in the action plan for the President's Memorandum on Building National Capabilities for Long-Term Drought

Resilience, which lays out a series of activities to fulfill the President's drought-resilience goals.⁴⁰

Conclusions

The Corps has revised some of the water control manuals used to operate its water resources projects, which serve important public purposes such as flood control, irrigation, and water supply. But district officials told us there are manuals that do not reflect the changing conditions in the areas surrounding the projects. A Corps engineer regulation states that the water control manuals should be reviewed no less than every 10 years and revised as needed. However, there is no Corps guidance on what activities constitute a review, and while district officials said they informally reviewed selected water control manuals through daily operations, they also said they do not document these reviews. Without developing guidance on what activities constitute a review of a water control manual and how to document that review, the Corps does not have reasonable assurance that its districts will consistently conduct reviews and document them to provide a means to retain organizational knowledge and mitigate the risk of having that knowledge limited to personnel directly involved with these reviews.

In addition, while the Corps has revised certain water control manuals in accordance with its engineer regulation, it does not track consistent information on revisions to its manuals. Furthermore, district officials said that they have requested funds to revise additional water control manuals as needed to reflect changing conditions, but they have not received those funds, and have not tracked consistent information about manuals needing revisions. However, internal control standards in the federal government call for agencies to clearly and promptly document transactions and other significant events from authorization to completion. Without tracking which manuals need revision, it is difficult for the Corps to know the universe of projects that may not be operating in a way that reflects current conditions as called for in the Corps' engineer manual and to prioritize revisions as needed. Because some manuals that need revision have not been revised and some district officials noted that operations for certain projects differ from aspects of the approved water

⁴⁰The White House, *Long-Term Drought Resilience: Federal Action Plan of the National Drought Resilience Partnership*, (Washington, D.C.: March 2016).

control plans in those manuals, the Corps lacks assurance that project operations are conforming to the objectives of authorizing legislation.

Recommendations for Executive Action

To help improve the efficiency of Corps operations at reservoir projects and to assist the Corps in meeting the requirement of the Water Resources Reform and Development Act of 2014 to update the Corps' 1992 reservoir report, we recommend that the Secretary of Defense direct the Secretary of the Army to direct the Chief of Engineers and Commanding General of the U.S. Army Corps of Engineers to take the following two actions:

- develop guidance on what activities constitute a review of a water control manual and how to document that review; and
- track consistent information on the status of water control manuals, including whether they need revisions, and prioritize revisions as needed.

Agency Comments

We provided a draft of this report for review and comment to the Department of Defense. In its written comments, reprinted in appendix I, the department concurred with our recommendations and noted that it will take steps to address these recommendations as it updates its guidance. In its comments, the department also stated that, as of May 2016, it had updated its Engineer Regulation 1110-2-240, *Engineering and Design: Water Control Management*. We incorporated this information into the report.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Defense, and other interested parties. In addition, the report is available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff members have any questions about this report, please contact me at (202) 512-3841 or fennella@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix II.

A handwritten signature in black ink that reads "Anne-Marie Fennell". The signature is written in a cursive style with a horizontal line underneath the name.

Anne-Marie Fennell
Director, Natural Resources and Environment

Appendix I: Comments from the Department of Defense



DEPARTMENT OF THE ARMY
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30 JUN 2016

Ms. Anne-Marie Fennell
Director, Natural Resources & Environment
U.S. Government Accountability Office
441 G. Street, NW
Washington DC 20548

Dear Ms. Fennell:

This is the Department of Defense (DoD), U.S. Army Corps of Engineers (USACE) response to the GAO Draft Report GAO-16-685, "ARMY CORPS OF ENGINEERS: Additional Steps Needed for Review and Revision of Water Control Manuals," dated June 10, 2016 (GAO Code 100281).

The Department appreciates this opportunity to review the report and is providing the following official written comments for clarification of the report contents and acknowledgment of recommended activities:

a. Pages 8 and 9: Reference to Engineer Regulation (ER) 1110-2-240, Engineering and Design: Water Control Management, as a 2014 document should be revised to be a 2016 document. At the time of the initial inquiry, ER 1110-2-240 was in draft form but was recently finalized, effective May 16, 2016.

b. DoD concurs with the recommendation for developing guidance on what activities constitute a review of a water control manual and how to document that review. This recommendation can be incorporated within our ongoing guidance update of Engineer Regulation, ER 1110-2-8156, "Preparation of Water Control Manuals."

c. DoD concurs with the recommendation to track consistent information on the status of water control manuals and will ensure the methodology for such action is taken into account during the update to the aforementioned ER 1110-2-8156.

Very truly yours,

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

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**GAO DRAFT REPORT DATED JUNE 10, 2016
GAO-16-685 (GAO CODE 100281)**

**“ARMY CORPS OF ENGINEERS: ADDITIONAL STEPS NEEDED FOR REVIEW
AND REVISION OF WATER CONTROL MANUALS”**

**DEPARTMENT OF DEFENSE COMMENTS
TO THE GAO RECOMMENDATION**

RECOMMENDATION 1: To help improve the efficiency of Corps operations at reservoir projects and to assist the Corps in meeting the Water Resources Reform and Development Act 2014 requirement to update its 1992 reservoir report, the GAO recommends that the Secretary of Defense direct the Secretary of the Army to direct the Chief of Engineers and Commanding General of the U.S. Army Corps of Engineers to: develop guidance on what activities constitute a review of a water control manual and how to document that review.

DoD RESPONSE: Concur with the recommendation for developing guidance on what activities constitute a review of a water control manual and how to document that review. This recommendation can be incorporated within our ongoing guidance update of Engineer Regulation, ER 1110-2-8156, “Preparation of Water Control Manuals.”

RECOMMENDATION 2: To help improve the efficiency of Corps operations at reservoir projects and to assist the Corps in meeting the Water Resources Reform and Development Act 2014 requirement to update its 1992 reservoir report, the GAO recommends that the Secretary of Defense direct the Secretary of the Army to direct the Chief of Engineers and Commanding General of the U.S. Army Corps of Engineers to track consistent information on the status of water control manuals, including whether or not they need revisions, and prioritize revisions as needed.

DoD RESPONSE: Concur with the recommendation to track consistent information on the status of water control manuals and will ensure the methodology for such action is taken into account during the update to the aforementioned ER 1110-2-8156.

Appendix II: GAO Contact and Staff Acknowledgments

GAO Contact

Anne-Marie Fennell, (202) 512-3841 or fennella@gao.gov

Staff Acknowledgments

In addition to the individual named above, key contributors to this report included Vondalee R. Hunt (Assistant Director), Cindy Gilbert, Richard Johnson, Cynthia Norris, Dan Royer, Holly Sasso, Jeanette Soares, and Michelle R. Wong.

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